Energization of the Open Field Lines in the Fast Solar Wind

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The origin of the energy and momentum observed in the fast solar wind has been a subject of great scientific interest for decades. The high-speed streams that permeate the heliosphere originate from large-scale coronal holes rooted in regions of seemingly unipolar photospheric magnetic fields. High resolution observations and theoretical models of turbulent magnetoconvection corresponding to solar granules (see left panel of Figure 1) show that what appears to be a unipolar field on large scales is actually a collection of very small-scale closed magnetic flux systems interspersed with regions of open field lines (see right panel of Figure 1).

The source of energy along the open field lines has been a source of scientific debate for some time, with some scientists arguing that the shaking of field lines by convective turbulence will excite Alfven waves that ultimately are dissipated as heat and drive the wind, while others argue that frequent intermittent reconnection events between small-scale closed loops with the open fields energize the open field and spew high density plasma onto the open field lines.

Recent 3-dimensional MHD simulations with the RADMHD code, which can self-consistently model the upper convection zone, photosphere, chromosphere and corona within a single code, and include all of the necessary physics to describe both the excitation of Alfven waves and the reconnection between open and closed field regions, show that we will be able to settle this long-standing dispute. These simulations are in progress now; a snapshot of early results is shown in Figure 1.

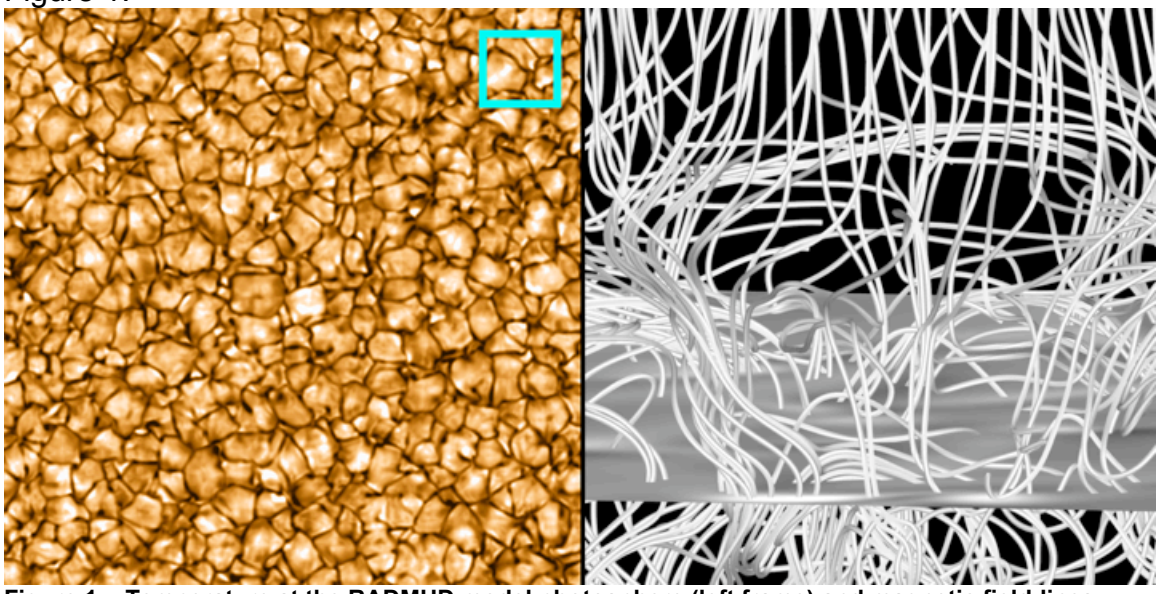

Figure 1 - Temperature at the RADMHD model photosphere (left frame) and magnetic field-lines threading the photosphere, chromosphere, transition region, and corona over a small computational sub-domain (the cyan box in the left frame indicates the approximate size of the sub-domain). The gray slice represents the approximate location of the model photosphere.